

**Mapping the Risk of Natural Resource Damage to Watersheds  
Associated with Wildland Fire and an Outbreak of the Southern  
Pine Beetle in Nueva Segovia, Nicaragua**

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# **Mapping the Risk of Natural Resource Damage to Watersheds Associated with Wildland Fire and an Outbreak of the Southern Pine Beetle in Nueva Segovia, Nicaragua**

## **Introduction**

Multiple natural disasters have continued to devastate the economy and natural resources of one of the poorest nations in the western hemisphere. In 1998, hurricane Mitch struck Nicaragua destroying half of the country's gross domestic product, killing 3000 people and destroying 11,500 hectares of agricultural lands. Another 25% of the country's cropland was further damaged and eroded by flooding. The U.S. Congress allocated \$103.6 million to address long-term recovery needs of Nicaragua.

The hurricane was followed by a devastating outbreak of the southern pine beetle, Dendroctonus frontalis Zimm in north central Nicaragua, resulting in large areas of watersheds in the providence of Nueva Segovia being at great risk of erosion. In an area which is already economically depressed, the formerly valuable pine forests have been devastated by bark beetle attack and wildland fire. Two years after the outbreak started, millions of pine (Pinus oocarpa and P. caribaea) trees litter the mountains of northern Nicaragua. An operational control project funded by USAID and implemented by INAFOR stopped the advance of the beetle in many areas. Harmful impacts to the current and future Nicaraguan timber industry have been incurred. Over 600 infestations were treated by cutting 5 million trees. Seventy percent of the forests, which controlled erosion and provided clean quality water no longer exist. This is especially critical in areas that are subject to extreme drought and flooding. There is almost no pine reproduction to replace the destroyed forest because of previous land use practices. Unless these valuable watersheds are restored, the area will suffer damaging erosion, water shortages, crop failures and a reduced output of forest products in the future.



**Figure 1. Area of high risk for future watershed damage located on steep slopes with pine bark beetle mortality subsequently burned by wildland fire in Nueva Segovia, Nicaragua**

The USDA Forest Service, Instituto Nacional Forestal (INAFOR), Universidad Nacional Agraria (UNA), the USDA Foreign Agriculture Service (FAS) and USAID have been cooperating for the past three years to reduce the damage caused by the pine beetle. USAID has provided funds to control the infestations, INAFOR has provided the personnel to implement the control operations, UNA has provided leadership in training and extension and the USDA Forest Service has provided technical assistance and geospatial analysis.

There is a need to identify areas that are at the greatest risk for future erosion so that plans can be made to protect and restore the watersheds. Currently, information is not available on the location of beetle-affected areas, the occurrence of wildfires and the location of the most important watersheds for the local communities. This information is necessary if rehabilitation of the affected areas is to be undertaken by the Nicaragua government and its cooperators.

Natural disasters like hurricane Mitch and the subsequent pine bark beetle outbreak and wildland fires are likely to set back many of the socio-economic gains that have been made in Nicaragua.

### **Objective**

The objective of this project is to prepare a map showing the areas of greatest risk for further environmental degradation due to the devastation caused by a combination of fire and a pine bark beetle outbreak in the Nueva Segovia, Nicaragua

### **Methods**

Geospatial data for the areas affected by the southern pine beetle outbreak and wildland fires in 2003 were obtained by UNA and INAFOR in the Nueva Segovia region of Nicaragua. These data were collected using GPS receivers while traversing the areas affected. Base cartographic data covering the areas of interests and other areas of Nicaragua were also provided by UNA and INAFOR, including vegetation cover, administrative boundaries, transportation networks, waterways, population centers, protected areas, and many others.

Digital Terrain and Elevation Data (NIMA Level I DTED) were obtained from the National Imagery and Mapping Agency (now National Geospatial-Intelligence Agency) to produce a shaded relief and slope category ArcGIS database. Slope categories were: 0-9 degrees; 10-19 degrees; 20-27 degrees; and greater than 27 degrees.

Geospatial analysis conducted on these data for Nueva Segovia included:

- Total area affected by bark beetles
- Total area burned
- Area affected by bark beetles and area burned by slope category
- Area affected by bark beetles and area burned by slope category in protected areas
- Area affected by both bark beetles and burned (coincident location) by slope category.

Areas considered to be at greatest risk to future damage by erosion would likely fall into the areas affected by both barked beetles and wildland fire on steep slopes. A map showing these areas was produced.

ESRI ArcGIS and ArcView software were used to conduct the geospatial analysis and preliminary map generation. Large format and report-sized maps were produced to display the results of these analyses. An ArcView database was produced and delivered to the cooperating organizations.

## Results

Bark beetle affected areas covered 57,921 acres (ac) or 23,440 hectares (ha). Total area burned in 2003 covered 13,650 ac or 5,524 ha. The areas of greatest risk for future damage to watersheds are considered to be on the steep slopes (areas >20 degree slope) containing both bark beetle mortality and subsequently burned, covering 299 ac. Other areas of high risk include the area affected by both bark beetles and burned covering 3,711 ac. Another categories of high risk include only beetle killed or burned areas on steep slopes. Table 1 shows the results of these analyses. Figures 2-5 are preliminary maps showing the locations of these areas of high risk for watershed damage.

**TABLE 1. Results of analyses of burned and beetle affected areas on slopes >20 degrees and in protected areas of Nueva Segovia, Nicaragua, 2003.**

	Total Area (Acres)	Protected Areas	Slopes >20 deg	Protected Area > 20 deg slope
Burned Area	13,650 ac 5,524 ha	3,138 ac 1,270 ha	1,893 ac 766 ha	460 ac 186 ha
Beetle Killed Pine	57,921ac 23,440 ha	17,945ac 7,262 ha	6,672ac 2,700 ha	3,882ac 1,571 ha
Burned w/Beetles (coincident)	3,711ac 1,502 ha	993ac 402 ha	299ac 121 ha	124 ac 50 ha
Burned & Beetles (Total)	67,860 ac 27,462 ha	20,090 ac 8,130 ha	8,266 ac 3,345 ha	4,218 ac 1,707 ha

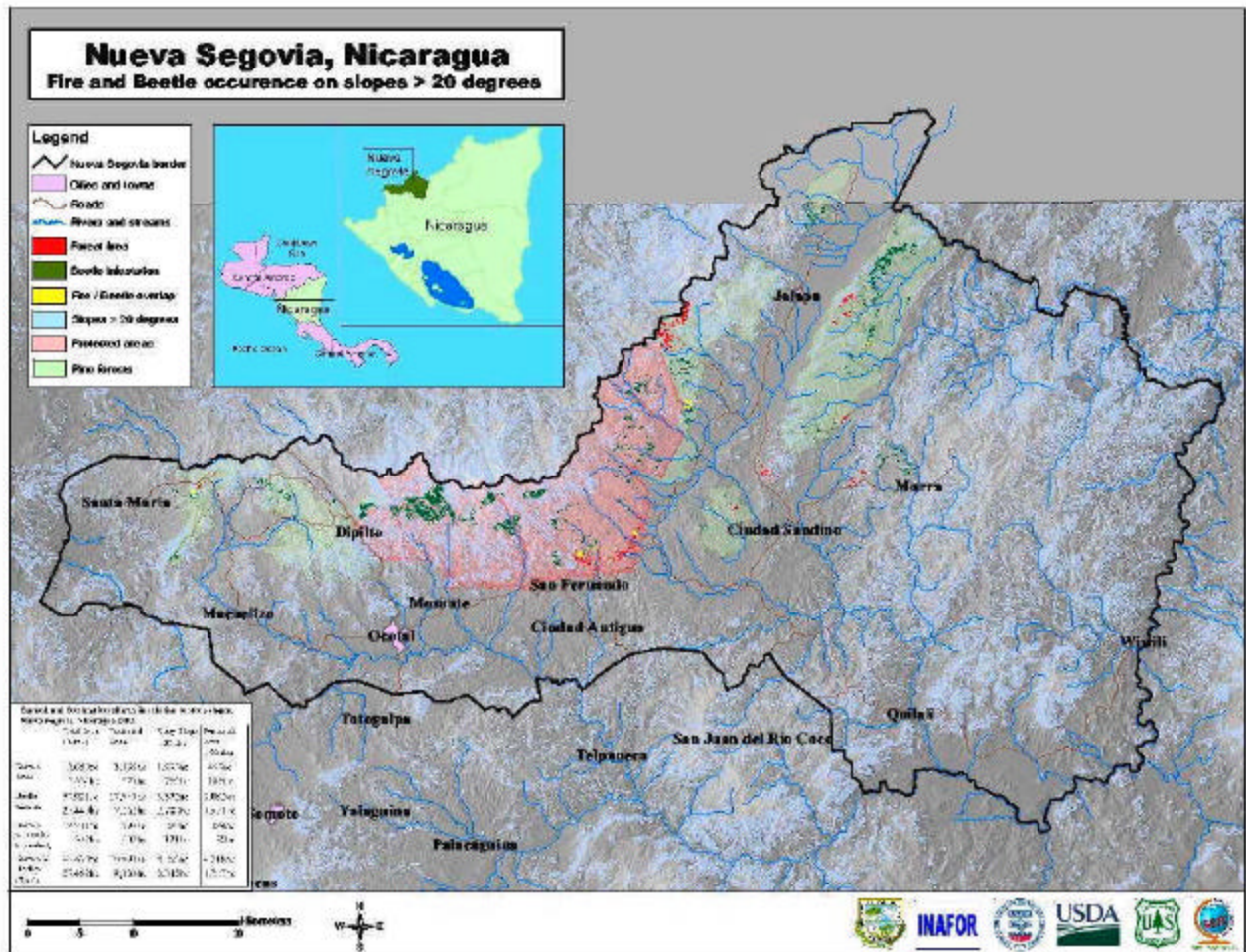
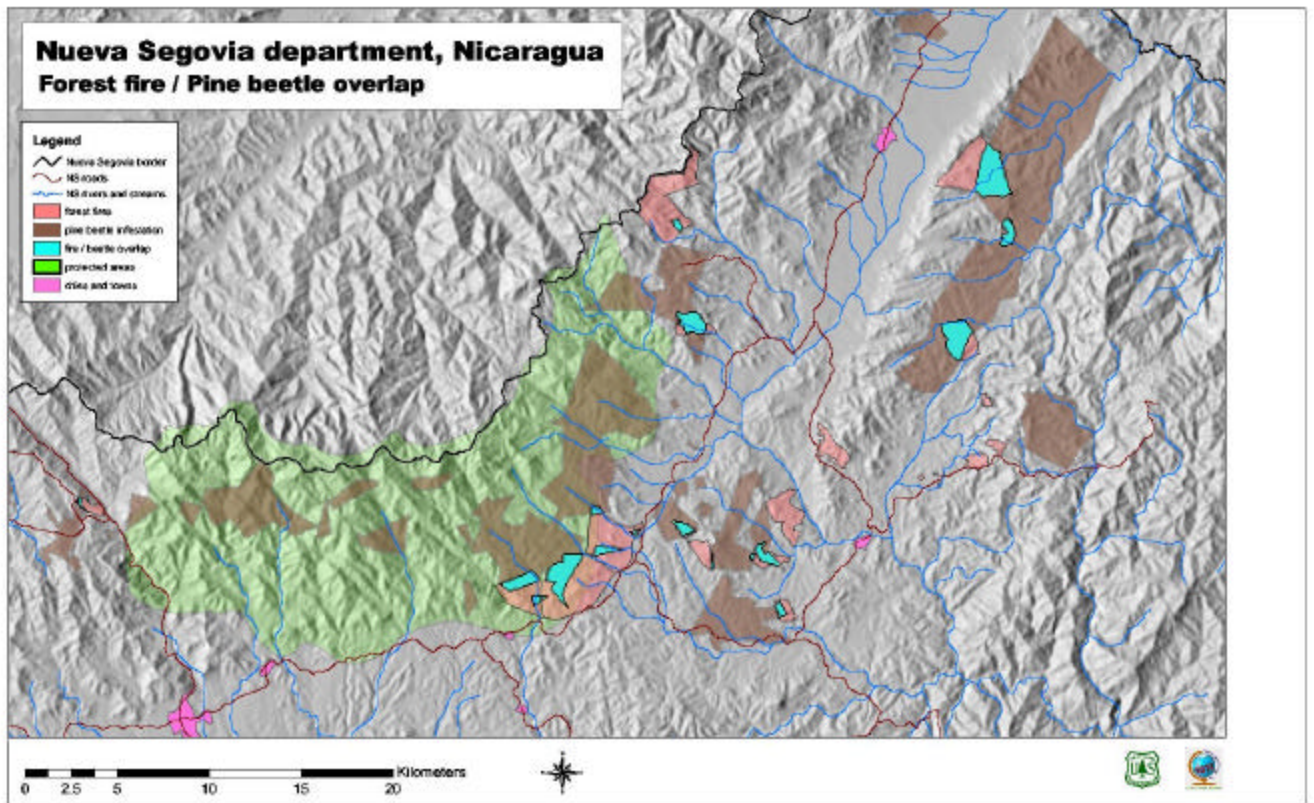
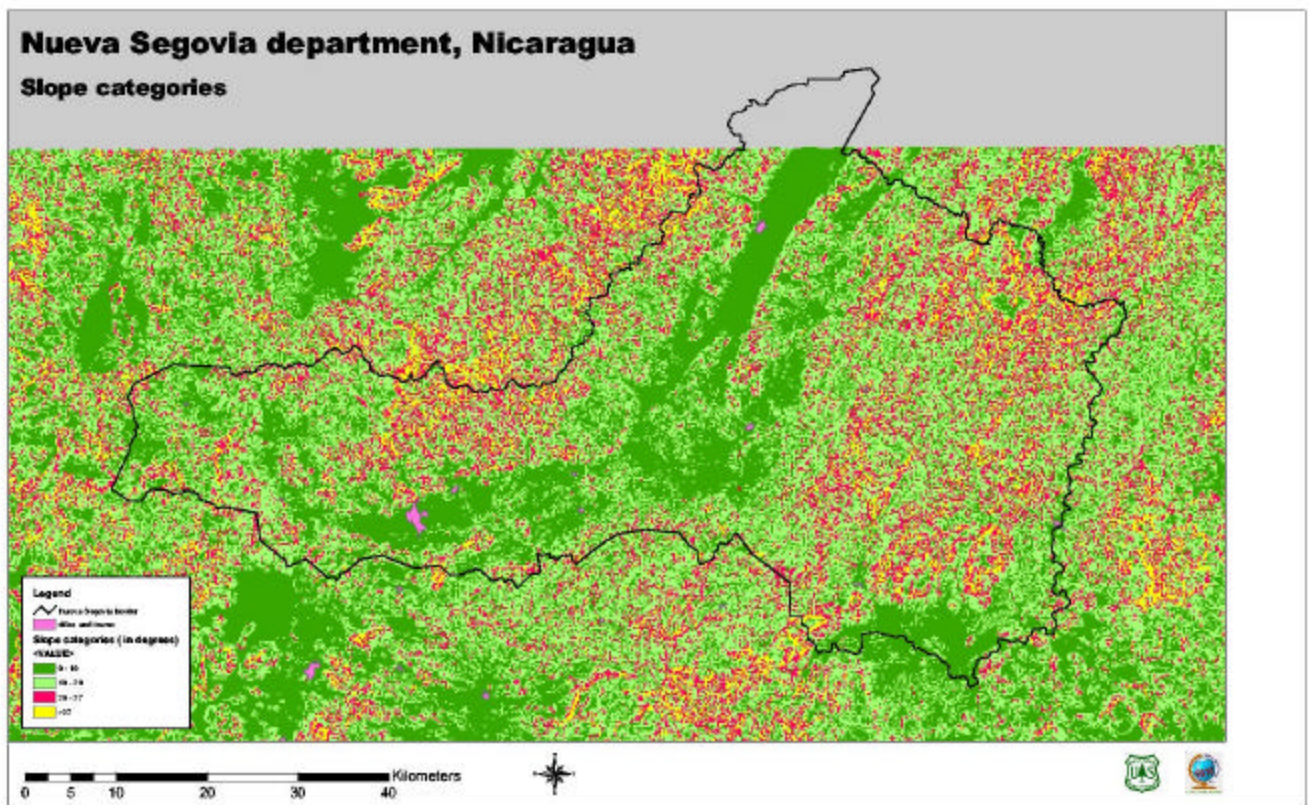


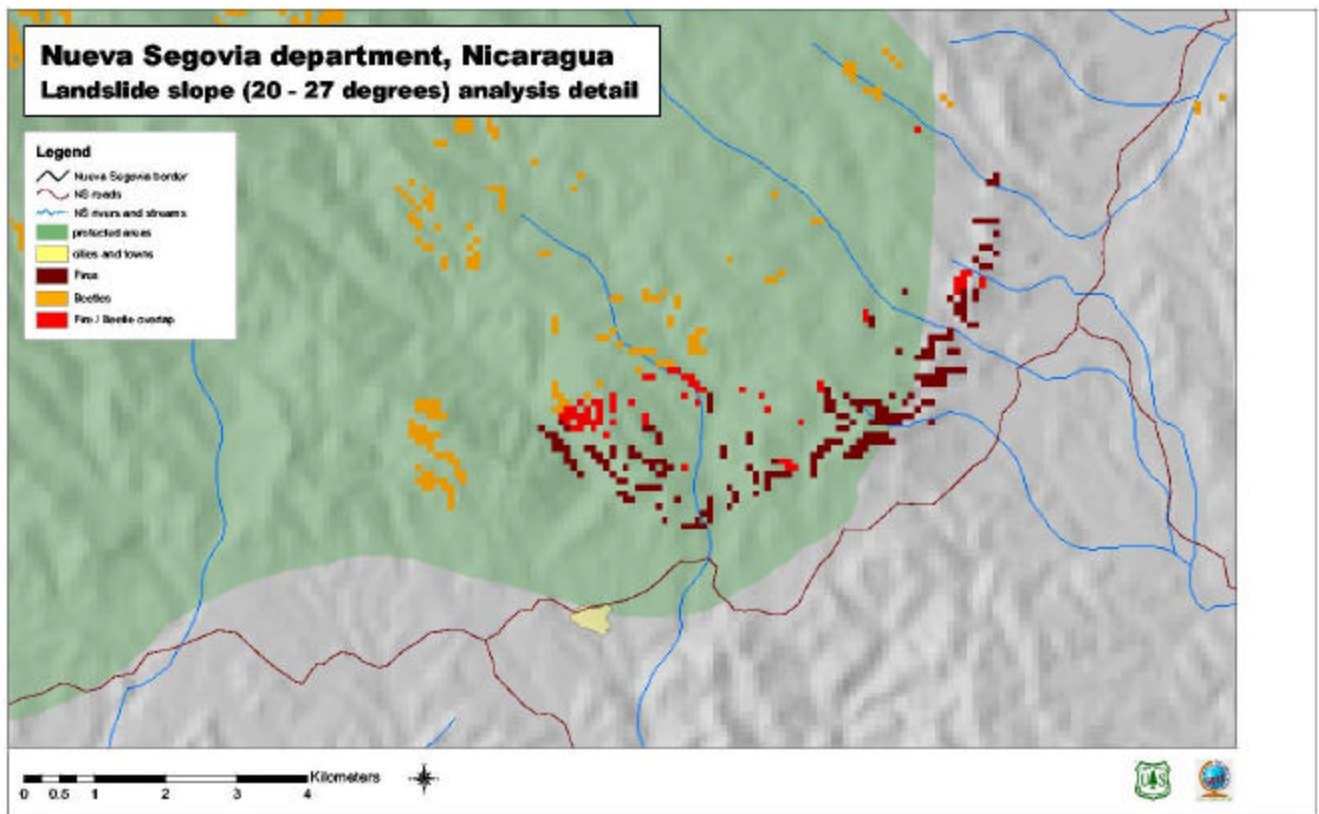
Figure2. Areas determined by GIS analyses displaying greatest risk for future damage to watersheds in Nueva Segovia, Nicaragua in 2003.



**Figure 3. Map displaying pine bark beetle and burned areas (and bark beetle / burned area overlap ) in Nueva Segovia, Nicaragua.**



**Figure 4.** Map displaying slope categories derived from DTED data in Nueva Segovia, Nicaragua.



**Figure 5. Map displaying areas at greatest risk for watershed damaged in and adjacent to protected areas.**

### **Recommendations**

- Reforestation should be considered in many areas shown as high risk on the maps produced in these analyses where natural regeneration has been destroyed by fires.
- The maps produced in these analyses should be ground truthed to validate the results.
- Data should be delivered to INAFOR and UNA for installation on cooperating organizations GIS . Training should be given on how to produce the necessary map products for use by resource managers in the rehabilitation of high-risk areas indicated by the analyses.
- Resource managers in Nicaragua should use the information gained from the GIS analyses to formulate plans and prepare proposals to rehabilitate damaged areas.
- Pine seedlings should be grown in nurseries between January to May and planted in areas of high risk later in the wet season in July.
- Incorporation of additional data layers such as soil and watershed information and other social/economic data should be considered to further refine the analyses
- A seminar should be held in to inform all cooperating organizations and potential donors of the results of these analyses and the need for protection and restoration of the high-risk areas.